MSW PROCESSING VESSEL

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DESCRIPTION

BACKGROUND OF THE INVENTION

[0001] Field of the Invention. The present invention generally relates to reprocessing municipal solid waste (MSW), and more particularly relates to reaction vessels for treating MSW in a heated and pressurized process.

[0002] Background Information. Handling solid waste is an increasingly difficult problem in the industrialized nations. Sixty-one percent of the United States' solid waste is dependent on disposal in landfills. However, nationwide the number of solid waste landfills is falling as the landfills fill to capacity and close, while new landfills cannot be opened due to regulations. The national average for solid waste disposal fees has increased by about 400 percent since 1985.

Such fees, called tipping fees, can be expected to raise an average of seven percent per year. In addition, the number of solid waste transfer stations has increased due to the closure of many landfills and the permitting of larger solid waste landfills.

[0003] These and other issues pertaining to the environmental impact that landfills will have in the future have prompted solid waste managers to seek methods to reduce volumes and disposal costs of municipal solid waste (MSW).

[0004] There have been a number of patents for treating and/or reprocessing MSW. These often involve some form of heat and pressure, and often a reaction vessel that may rotate. Although MSW varies in composition, there is a certain norm to its content. Cellulosic material represents approximately seventy percent of the bulk of typical MSW. Other terms for this fraction of MSW have been used, including putricible, organic, and biomass. These terms are considered interchangeable and it is to be understood that the use of the term cellulosic in this application encompasses all those terms.

[0005] The participle, biomass, organic, or cellulosic fraction of MSW includes all portions that are organic, which would eventually decay in a landfill and the decay would eventually lead to the production of methane gas. If this cellulosic material can be separated from the rest of the

MSW and reformulated into reusable products, much of the solid waste problems will be alleviated. Products that can be made from the cellulosic fraction of MSW include pelletized fuel, composite building products, and biomass for refineries. The cellulosic fraction of MSW could also conceivably serve as a source of hydrogen generation for use of hydrogen as a fuel.

[0006] Once the cellulosic material is removed, the MSW waste stream is much reduced in volume and other recoverable fractions of the waste stream can be recovered. Ferrous, non-ferrous, plastics, and textiles can represent an additional fifteen percent of the remaining MSW waste stream.

[0007] There are processes available that can recover each of these materials and send them to the respective market. If the cellulosic and recoverable waste streams are removed from MSW, the volume of MSW going to landfills is typically less than fifteen percent of the original amount. This reduction in volume reduces hauling costs, landfill space requirements, and the eventual expense of closing a landfill and opening a new one. The process and device also accomplish this reduction while reducing effluents, including methane and leachate. Further, if the cellulosic portion is removed from MSW, the remaining fraction in inorganic and may be disposed of in waste sites reserved for construction or other inorganic waste, which is space that is less constrained and therefore less expensive.

[0008] Many prior art reaction vessels for treating MSW utilize fairly high-pressure steam in order to cook and soften the cellulosic fibers of the MSW. This presents a problem because high-pressure steam vessels require significant licensing and inspection regimes, and must be built to withstand the excessive pressure. If the reaction vessel can achieve adequate softening, pulverization, and separation of cellulosic fibers while utilizing low pressures, the vessel could be lighter, less expensive, and much more easily licensed and permitted. A low-pressure reaction vessel that achieves adequate softening, pulverization, and separation of cellulosic fibers is thus needed.

[0009] What is also needed is a reaction vessel that incorporates condensation of gaseous affluent steam from the reaction vessel. This reduces any water waste stream from the vessel, and also reduces or eliminates unpleasant gas emissions from the vessel.

[0010] There is also a need in the industry to provide a vessel processing system that results in a product with fairly low moisture, provides a sterilization effect upon the MSW, and imparts beneficial processing steps to the non-cellulosic waste fractions. This includes removing labels from containers, fracturing glass for later separation from the waste stream, compacting and agglomerating plastics, and compacting aluminum waste.

[0011] Additional objects, advantages, and novel features of the invention will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art upon examination of the following or may be learned by practice of the invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

SUMMARY OF THE INVENTION

[0012] The MSW treatment vessel of the present invention achieves these and other objects. The vessel includes a generally cylindrical reaction vessel with a first end and a second end. The vessel is configured for rotation, which is achieved through the use of one or more support tracks, wheels, and designated trunnion assemblies to support the reaction vessel as it rotates. It also has a drive mechanism for powering the rotation of the reaction vessel and its contents.

[0013] The MSW treatment vessel of the present invention includes at least one access opening through which MSW may be loaded into the reaction vessel. If only one access opening is utilized, MSW also exits the reaction vessel through the same opening. If two access openings are used, one would be at one end of the reaction vessel and the other would be at the other end. MSW would enter the vessel at one opening and exit through the other opening. The reaction

vessel includes a door assembly, which is adjacent one or more of the access openings, for closing the access openings and holding the door closed against pressure within the vessel.

[0014] The MSW treatment vessel includes one or more flights of auger vanes on the interior wall of the reaction vessel for moving MSW from the first end to the second end of the vessel. If the vessel is constructed with only one access opening, then the flights, through rotation of the vessel, cause the MSW to move from one end of the reaction vessel to the other and back again towards the door opening. The auger vanes have a base edge, which is attached to the interior vessel wall, typically by welding. Of course brackets or studs or other known attachment methods can also be used for this purpose.

[0015] The auger vanes also have a top edge, with the top edges of the auger vanes defining a bore parallel to the long axis of the reaction vessel. The bore has a diameter that is approximately one third of the diameter of the reaction vessel, when seen in cross section. This means that the space defined by the auger vanes occupy about two thirds of the cross sectional diameter of the reaction vessel.

[0016] An important feature of the reaction vessel is a number of raised projections that extend from the top edges of auger vanes. As the reaction vessel turns and MSW tumbles within

the auger vanes, the raised projections on the top edges of the auger vanes aid in moving, pulverizing, and shredding the MSW. These raised projections can be generally trapezoidal or triangular in shape, with one edge attached to the auger vane top edge. If triangular, the point of a triangle projects away from the top edge of the auger vane.

[0017] The raised projections can also be oriented in a plane generally normal to the plane of the auger vane. This results in raised projections perpendicular to the auger vane and parallel to the long axis of the reaction vessel. These projections can point in one or both directions from their attachment point on the auger vane top edge, resulting in jagged teeth pointed backward and forward perpendicular to the general orientation of each auger vane.

[0018] The auger vanes can be constructed to be one continuous spiral from one end to the other of the reaction vessel. The auger vanes can also be broken into a series of arching vanes, with each section welded or otherwise attached to the interior wall of the reaction vessel and contributing to the auger effect during rotation of the vessel.

[0019] The reaction vessel can be considered to have three sections. The first section is adjacent to the access opening. The second section is positioned in the middle of the reaction vessel. The third section is positioned at the end of the reaction vessel opposite the access

opening. The most important location for the raised projections is in the third section of the reaction vessel. Thus, a reaction vessel could be built with raised projections in the third section, or in the third and second sections, or in all three sections of the reaction vessel.

[0020] The reaction vessel includes a steam injection system by which steam is injected into the vessel via steam tubes that run along the sides of the reaction vessel parallel to the long axis of the reaction vessel. Thus, the steam sparging tubes penetrate the auger vanes where the auger vanes are attached to the vessel wall. The steam sparging tubes receive their steam from a circular steam manifold that connects to all of the steam tubes. The steam manifold rotates with the vessel and is attached to a rotary joint through which steam is injected into the steam manifold and the vessel. The steam sparging tubes can extend the entire length of the vessel and can extend out the end of the vessel opposite from the end in which the steam is injected. The steam sparging tubes include orifices through which steam is introduced to the interior of the vessel.

[0021] The MSW treatment vessel of the present invention also preferably includes an effluent condensation system. Part of the effluent condensation system is a steam eductor. The steam eductor operates on the principal that when air is blown into a cone, it creates a vacuum. In this case, the vacuum pulls the steam, previously injected into the vessel, from the vessel into

a condensing chamber where condensation takes place.

[0022] The condensation system is achieved by putting the steam from the processor in contact with a cooler media that will cause the steam to cool and condense. The condensing of the steam thus creates a vacuum.

[0023] The MSW treatment vessel includes a swing away door assembly, which is adjacent the access opening. The door assembly includes a swing away door, which covers the access opening, and a davit assembly for supporting the swing away door. The davit assembly includes a generally vertical davit upright, which supports the door through a generally horizontal door support arm. The support arm has a first end and a second end with a counterweight attached to the first end and the access opening door attached to the second end. The davit assembly is configured to rotate around the davit upright so the access opening door may be rotated away from or toward the access opening. This can be accomplished by manual rotation of the davit assembly or it can easily be automated.

[0024] The MSW treatment vessel further includes one or more chain sections that are attached to the interior of the vessel. These are attached in various lengths, but typically two to six feet is sufficient to accomplish the purpose, while three to four feet has also proven effective.

The chains would be sized according to the size and capacity of the reaction vessel, but a thickness of ¾ inches has proven successful for one preferred embodiment. The chains are attached so that they hang freely in the MSW treatment vessel. A chain detachably attached to the auger vane about every six feet is a preferred configuration. When the vessel rotates, the chains assist in agitating, pulverizing, and mixing the MSW contained within the vessel.

[0025] In a vessel that utilizes one access opening, the vessel is configured to rotate in one direction to load, pulverize, and heat process the MSW. The rotation of the reaction vessel is then reversible to further pulverize and move the MSW toward the access opening end for removal of the MSW through the access opening.

[0026] The door sealing system of the vessel includes a first raised locking rim, which surrounds the access opening. This first raised locking rim corresponds with a second raised locking rim, which surrounds the access opening door, which will be referred to as simply the door. When the door is placed adjacent the access opening, the first locking rim is side-by-side with the second locking rim, which is on the door itself. The door sealing system includes a clamp collar for sealing the two locking rims together. Thus, it holds the access opening door over the access opening. The clamp collar can further include a first section and a second section with one or more joining devices for joining the two sections together. The joining devices can

be one or more clamp screws that draw the first and second clamp sections and thus hold them together until released. The clamp screws move through threaded bosses on the sides of the clamp collar sections. The door closing assembly can comprise two clamp screws, which are mounted on corresponding bosses on the sides of the first and second clamp sections. These are driven by one or more motors to pull the collar sections together through the use of threaded screws.

[0027] The first and second locking rim can each include a bevel. The first bevel surface would be located on a side opposite the contact surfaces of the locking rims. The second bevel surface would be located on the second locking rim also on the side of the locking rim away from the contact surface. The clamp collar sections can include a corresponding angled surface, which would interact with the first and second bevels of the first and second locking means. As the clamp collar sections close on the locking rings, the angled surfaces would tend to guide the door into alignment with the access opening.

[0028] The invention also comprises a method for treating MSW for fiber recovery. The method includes the steps of putting MSW in a generally cylindrical reaction vessel, in which the vessel has internal auger vanes for moving, mixing, shredding, and pulverizing MSW. The reaction vessel of the method has auger vane edges that define a bore, having a cross sectional

diameter approximately one-third the cross sectional diameter of the vessel.

[0029] The MSW is loaded into the reaction vessel away from the access opening through rotation of the reaction vessel and its auger vanes. When sufficient MSW is loaded into the reaction vessel, the reaction vessel is closed and the atmosphere inside the vessel is evacuated through the distillation system of the device. Then, steam is injected into the reaction vessel and heat and pressure slowly build up. A steam pressure of less than fifteen pounds has been found to be suitable for the purposes of this method. The reaction vessel is rotated, while steam is injected for a period of time to soften the fibers of cellulosic waste within the MSW. Steam is injected at fifteen pounds or less through the steam sparging lines in the vessel. Although the method can operate under varied conditions depending on the particular blend of MSW being treated, a reaction time of approximately fifteen to forty-five minutes has been found to be sufficient to soften the fibers of most MSW. After this time has been reached and sufficient time has been allowed for churning, shredding, and pulverizing the MSW, the steam is evacuated through the use of a steam eductor system. The steam eductor system includes an air nozzle and operates by airflow through an orifice that crates a vacuum.

[0030] The steam in the internal atmosphere from the vessel is thus removed through a barometric condenser before the vessel is opened in order to reduce the volume of escaping

emissions from the vessel. After evacuation is accomplished, the door is removed and the MSW is removed by rotation of the vessel and propelled by the action of the auger vanes. After being removed from the reaction vessel, the MSW is treated for separation of the cellulosic fiber components from other materials such as plastic, aluminum, glass, and various metal components. The separation processes that are well known in the industry separate each of these streams, which is the subject matter of other patents and practices.

[0031] Further, the purpose of the foregoing abstract is to enable the United States Patent and Trademark Office and the public generally, and especially the scientists, engineers, and practitioners in the art who are not familiar with patent or legal terms or phraseology, to determine quickly from a cursory inspection the nature and essence of the technical disclosure of the application. The abstract is neither intended to define the invention of the application, which is measure by the claims, nor is it intended to be limiting as to the scope of the invention in any way.

[0032] Still other objects and advantages of the present invention will become readily apparent to those skilled in this art from the following detailed description wherein I have shown and described only the preferred embodiment of the invention, simply by way of illustration of the best mode contemplated by carrying out my invention. As will be realized, the invention is

capable of modification in various obvious respects all without departing from the invention. Accordingly, the drawings and description of the preferred embodiment are to be regarded as illustrative in nature, and not as restrictive in nature.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] Fig. 1 is a perspective view of the MSW processing vessel.

[0034] Fig. 2 is a perspective view of the second end of the MSW processing vessel.

[0035] Fig. 3 is front view of the davit and door assembly.

[0036] Fig. 4 is a top view of the davit and door assembly.

[0037] Fig. 5 is a perspective view of an auger vane with projections.

[0038] Fig. 6 is an end view of a cross section of the vessel.

[0039] Fig. 7 is an elevation view of the reaction vessel.

[0040] Fig. 8 is an end view of the reaction vessel.

[0041] Fig. 9 is a view of the closing action of the door assembly.

[0042] Fig. 10 is a view of the door closed against the access opening.

[0043] Fig. 11 is a view of the effluent system.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0044] While the invention is susceptible of various modifications and alternative constructions, certain illustrated embodiments thereof have been shown in the drawings and will be described below in detail. It should be understood, however, that there is no intention to limit the invention to the specific form disclosed, but, on the contrary, the invention is to cover all modifications, alternative constructions, and equivalents falling within the spirit and scope of the invention as defined in the claims.

[0045] Some of the preferred embodiments are shown in the Figs. 1 through 11. Fig. 1 shows the MSW treatment vessel 10. It includes a reaction vessel 12. In one preferred mode of the invention, a first trunnion assembly 14 and a second trunnion assembly 16 support the reaction vessel 12. The trunnion assembly includes a track 18 and a trunnion 20. These components can be sized according to the size of a specific reaction vessel. However, in a preferred embodiment of the vessel, the trunnions are cylinders of solid steel approximately fifteen inches in diameter and approximately ten inches in length.

[0046] The reaction vessel also includes a gear ring 22, which is driven by a motor and a drive gear. A preferred embodiment of the gear ring is approximately ten inches wide and is made of steel approximately five inches thick. While a geared drive system is preferred, other

drive systems would also work, including a chain and sprocket drive or a cradle formed by a chain and sprocket under the vessel.

[0047] The reaction vessel 12 can take a number of configurations with different sizes depending upon the desired capacity and throughput of the operation. One preferred configuration of the reaction vessel is approximately fifty feet long and eight feet in diameter. It is made generally of one-half inch steel plate with one and one-fourth inch reinforced steel plate in the region of the trunnion assemblies 14, 16 and the track 18. The reaction vessel has a rounded ellipsoidal head at the second end 22 of the reaction vessel. At the first end 24 of the reaction vessel, the vessel tapers from approximately an eight foot diameter to approximately a four foot diameter, opening on a frustoconical section approximately five feet in length. A cylindrical collar 28 with a first locking ring 30 is at the narrow end of the frustoconical section 26. Shown adjacent the first locking ring 30 in Fig. 1 is the door 32, which includes a second locking ring 34.

[0048] A spiraling auger vane 36 is inside the reaction vessel 12. This is preferably made of one-half inch thick steel, welded at its base edge to the interior of the reaction vessel wall. The top edge of the auger vanes extends away from the reaction vessel wall towards the center of the reaction vessel 12. Although the auger vane is shown in Fig. 6 as being one continuous spiral

from the first end 24 to the second end 22, the auger vanes could also be constructed of several disconnected sections, which together form a spiraling configuration attached to the inside wall of the reaction vessel. The auger vanes can be attached to the interior vessel walls by welding or by attachment to brackets mounted to the interior vessel wall. This latter arrangement would allow easier replacement of the vane sections.

[0049] In one preferred embodiment of the present invention, the auger vanes extend into the interior of the reaction vessel 12 and their top edges form the outline of a bore. The diameter of the bore is approximately one-third of the diameter of the reaction vessel of a particular cross section of the reaction vessel. Fig. 2 shows such a cross section of the reaction vessel with the bore 38 being approximately one-third the diameter of the vessel 10.

[0050] Fig. 1 shows the door 32 of the vessel. The door 32 is also seen in Figs. 3, 4, and 7. In the preferred mode, the door 32 is approximately four feet in diameter and, as shown in Fig. 7, is ellipsoidal in shape. The door 32 includes a second locking ring 34. The door is closed to the access opening by a clamp collar 40. In the preferred embodiment of the invention, the clamp collar is made of a semicircular first section 42 and a semicircular second section 44. On each of the clamp sections are two threaded bosses 46. Each of these correspond with the threaded bosses on the opposite clamp collar section. A first and second clamp collar screw 48 and 50

pass through the threaded bosses on the clamp collars. When the screws 48, 50 are turned, the first and second sections of the clamp collar are drawn together. This locks the door 32 to the access opening 52 of the reaction vessel 10. Figs. 9 and 10 show this closing operation more closely. In one preferred embodiment of the invention, the clamp collar screws are approximately one and one-fourth inch in diameter and approximately twenty-five inches in length.

[0051] The preferred embodiment of the invention includes a davit assembly 54, as shown in Fig. 1. The davit assembly 54 includes a davit upright 56 and a door support arm 58 with a first end 60 and a second end 62. A counterweight 64 is attached to the first end 60 of the door support arm 58. The door 32 is attached to the second end 62 of the door support arm 58. The configuration of the components of the davit assembly 54 would vary in size depending on the size of the insulation and the size of the door 32 they were associated with. One particular configuration that has proven successful is one with the davit upright being made of approximately six inch diameter tube with the door support arm 58 being made of approximately four inch diameter steel tube. The counterweight in this configuration will vary to match the weight of the associated door 32, but, in one preferred embodiment, the counterweight 64 is made of steel and weighs approximately 250 pounds. The door support arm 58 attaches to the davit upright 56 by means of a T-connection 66. The T-connection 66 is rotatable about the davit

upright 56 and includes a bearing (not shown) for rotation.

[0052] In one preferred embodiment of the invention, the first and second clamp collar screws 48, 50 are turned by one or more motors that are located in a motor housing 68. An approximately three horsepower motor is sufficient for one embodiment, operating through a gearbox.

[0053] Fig. 3 shows a front view of the davit assembly 54 attached to the door 32. In this view, the first section clamp collar 42 and the second section clamp collar 44 are in the open position, so that the door 32 may swing away from the access opening 52.

[0054] Fig. 4 shows a top view of the davit assembly 54. In the position shown in solid lines, the davit assembly 54 and the attached door 32 are in a closed position. The door is positioned adjacent the first locking ring 30, which surrounds the access opening on the cylindrical collar 28. Cylindrical collar 28 is attached to the frustoconical section 26.

[0055] The preferred embodiment of the invention includes raised projections that extend from the edges of the auger vanes. These can extend vertically or horizontally from the top edge of the auger vanes. A preferred embodiment is with projections extending in both directions

perpendicular from the auger vanes. Such projections can be triangular, trapezoidal or other shapes to form a jagged cutting edge. If trapezoidal or triangular, they can extend approximately one inch from the auger vane to which they are attached, with a base edge of approximately one inch. If trapezoidal, the edge parallel to the base edge can be three-quarter of an inch in width. The projections are preferably approximately one-quarter inch thick steel welded to the edge of the auger vanes. Fig. 5 shows trapezoidal projections attached to the auger vane edge. Fig. 5 shows a perspective view of a section of auger vane 36 of the present invention. Attached to this section of auger vane 36 are a number of raised projections 70 that are joined together as a unit and mounted to top edge 72 of the auger vane. The base edge 74 of the auger vane is welded to the interior wall of the reaction vessel 12. A number of these projections are attached to the top edge of the auger vane and can be parallel with the auger vane or, as shown in Fig. 5, can be perpendicular to the auger vane and pointing in both directions. As the auger vane turns, MSW is pushed against the auger vane and projection 70 and tumbled from one section of the reaction vessel 12 to another. This allows the raised projections 70 help shred and pulverize the MSW. This is especially true after the MSW has been subjected to heat and steam, and the cellosic fibrous materials are soft and shredable.

[0056] Fig. 6 is a view of the second end 22 of the reaction vessel 12. In one preferred embodiment of the present invention, a gear ring 76 interacts with a drive gear 78 and a motor 80

to rotate the entire reaction vessel 12. Also seen on the second end 22 is a rounded ellipsoid head. Steam is injected into the vessel through a circular steam sparger manifold 82. Steam is injected into the sparger manifold 82 by means of a rotary joint 84 and a steam connector line 86. From the sparger manifold 82, a number of sparger lines 88 extend into the interior of the reaction vessel 12. In this configuration, these sparger lines are straight and attached to the interior wall of the reaction vessel 12. These lines are also shown in Fig. 7. While they are shown in Fig. 7 as protruding through the opposite end of the reaction vessel and being terminated there, the ends of the sparging lines could also be linked to each other so that if an obstruction blocked one sparging line, the line could be pressurized beyond the obstruction from the other end.

[0057] Fig. 7 is an elevational view of the MSW treatment vessel 10. Shown is the reaction vessel 12 with a first trunion assembly 14 and a second trunion assembly 16. The first end 24 of the reaction vessel includes a frustoconical section 26, a cylindrical collar 28, and a first locking ring 30. Auger vanes 36 are shown attached to the inner wall of the reaction vessel and form a spiral the length of the reaction vessel 12. The height of the auger vane decreases towards the first end 24. At the second end 22 of the reaction vessel, a circular steam sparger manifold 82 is seen. This connects to a steam connector line 86 and a rotary joint 84. A number of sparger lines 88, which extend into the reaction vessel 12, extend from the steam sparger manifold 82.

Orifices (not shown) in the sparger lines 88 allow steam to exit the sparger lines into the reaction vessel 12.

[0058] The first trunion assembly 14 includes trunions 20 and tracks 18, which circumvolve the reaction vessel 12. The reaction vessel 12 is turned by a motor 80, which drives a drive gear 78 that interacts with a gear ring 76 attached to the reaction vessel 12, causing the reaction vessel 12 to rotate on the trunion assembly. It is to be understood that although two trunion assemblies are shown, a pair of trunions at each trunion assembly supports the reaction vessel 12. Thus, each tract is supported by two trunions and, in this embodiment, the reaction vessel is supported by four trunions.

[0059] Fig. 8 shows an end view of the first end 24 of the reaction vessel 12. Shown is the gear ring 76, which circumvolves the reaction vessel 12. The door 32 is shown in its position covering the access opening. The first section 42 of the clamp collar is shown, as well as the second section 44 of the clamp collar. The first clamp collar screw 48 and the second clamp collar screw 50 are shown. The clamp collar 40 is shown in an open position in solid lines and in a closed position in dashed lines. As shown, the clamp collar screws 48, 50 extend from a motor housing 68 in which preferably two separate motors turn the clamp collar screws and cause the sections of the clamp collar to come together or move apart. Trunnion 20 is shown supporting

the reaction vessel 12. Also shown is drive gear 78, which is driven by a motor 80.

[0060] Fig. 9 is a cross sectional side view of the door locking action of the reaction vessel. Shown is a portion of frustoconical section 26 and cylindrical collar 28 of the reaction vessel. The first clamp collar section 42 is shown. Also shown is the first locking ring 30 and the second locking ring 34, which is attached to the door 32. As shown in Fig. 9, the door 32 is adjacent to but not sealed against the first locking ring 30. The first section clamp collar 42 is adjacent to but not engaged with the first and second locking rings 30 and 34. The second section clamp collar 44 would be similarly positioned. As the first section 42 of the clamp collar moves down and around the first and second locking rings 30 and 34, it moves into the configuration shown in Fig. 10. In Fig. 10, the first section clamp collar 42 has moved into engagement with the first locking ring 30 and the second locking ring 34. The first locking ring 30 includes a bevel surface 94 and the second locking ring 34 includes a bevel surface 96 to assist in position the door. In the position shown in Fig 10, the clamp collar has forced the two locking rings together and holds them together in a sealed configuration. A gasket 90 is present in a recess 92 in the second locking ring 34. The bevel surfaces 94, 96 interact with corresponding beveled surfaces 98, 100 in the interior channel 102 of the first clamp collar 42. Although only one clamp collar is shown, it is to be understood that the preferred embodiment of the invention utilizes two semicircular clamp collars which bring the door into sealed engagement with the access opening as shown in

Figs. 9 and 10.

[0061] Fig. 11 shows a view of the effluent system. The effluent system in the processing vessel of the invention includes a steam eductor 110 and a barometric condenser 112. The barometric condenser 112 can take various forms and would of course be sized according to the particular design of the reaction vessel. One version of the barometric condenser 112 can include a condensation tank, which is approximately three feet in diameter and six feet tall, and is oriented vertically. A connection between the tank and the reaction vessel is made so that steam from the reaction vessel can be allowed to enter the tank at a point about two thirds from the bottom of the tank. As the steam 118 from the reaction vessel enters the tank, it is condensed. This can be done in several ways. A very effective method is to spray water 116 from the top of the tank onto the steam 118. This not only condenses the gaseous steam into a condensate liquid 120, but in doing so, also creates a vacuum, which pulls more steam from the reaction vessel. One effect of this is that the volume of effluents from the barometric condenser 112 is increased, and the concentration of contaminants from the steam is decreased. There is also a drain valve 114 for removing the condensate 120.

[0062] Other methods of condensing water from the steam are also possible, such as having the steam hit tubes filled with a cool liquid, which would require a refrigeration unit to keep the

liquid in the tubes cool. Cold air can also be injected into the condensation tank, which would result in less volume of eventual effluent, but with a higher concentration.

[0063] The steam eductor is the device that extracts the atmosphere from the reaction vessel and directs it into the barometric condenser. The steam eductor can take a number of forms including an air pump, venturi tube or any other commonly used devices that move air. The steam eductor would be utilized to remove as much steam from the reaction vessel as possible before it is opened. The removal of this atmosphere can continue until there is a negative pressure in the reaction vessel.

[0064] Even with a thorough evacuation and flushing of the atmosphere from the reaction vessel, when the door to the reaction vessel is opened and the MSW is moved by the augers to the opening, the act of stirring, tumbling, and moving the MSW by the reaction vessels and the augers, the MSW will release significant quantities of steam. To capture this steam, a hood, which is placed over the door to the reaction vessel so that effluents from the MSW can be enclosed in the hood and drawn off to the barometric condenser, is useful. Typically, the MSW from the reaction vessel is directed to a trommel screen for sorting of the material. While the recently heated MSW is on the trommel screen and being moved, steam will continue to be released. A hood over the trommel screen is effective at this point to contain steam and gaseous

effluents, and to allow them to be channeled to the barometric condenser.

[0065] While there is shown and described the present preferred embodiment of the invention, it is to be distinctly understood that this invention is not limited thereto but may be variously embodied to practice within the scope of the following claims. From the foregoing description, it will be apparent that various changes may be made without departing from the spirit and scope of the invention as defined by the following claims.